Setting up Simulations of Failure Scenarios for a Crab Cavity in the Nominal LHC.

Tuesday 23 Nov 2010 at 19:20 (00h20')

The Crab Cavity (CC) represent a possible solution for the problem of the reduction of the luminosity due to a crossing angle. The CC apply a transversal kick on the beam particles that varies with the longitudinal position along the bunch in order to produce a head-on collision and increase the geometry luminosity. For that reason the people of BE-ABP has been developed studies for the implementacion of the CC in the LHC. Because the CC is a superconducting RF cavity is essential to study the failures scenarios and the damage that it could be generate to the lattice. So for that reason we set up the simulations of these failures of the CC in the nominal LHC.

Primary authors : Mr. BRUCE, Yee Rendon (student)

Co-authors :

Presenter : Mr. BRUCE, Yee Rendon (student)

Setting Up Simulations of Failure Scenarios for a Crab Cavity in the Nominal LHC

Bruce Yee Rendón

Departamento de Física
Centro de Investigación y de Estudios Avanzados
del Instituto Politécnico Nacional Unidad Zacatenco

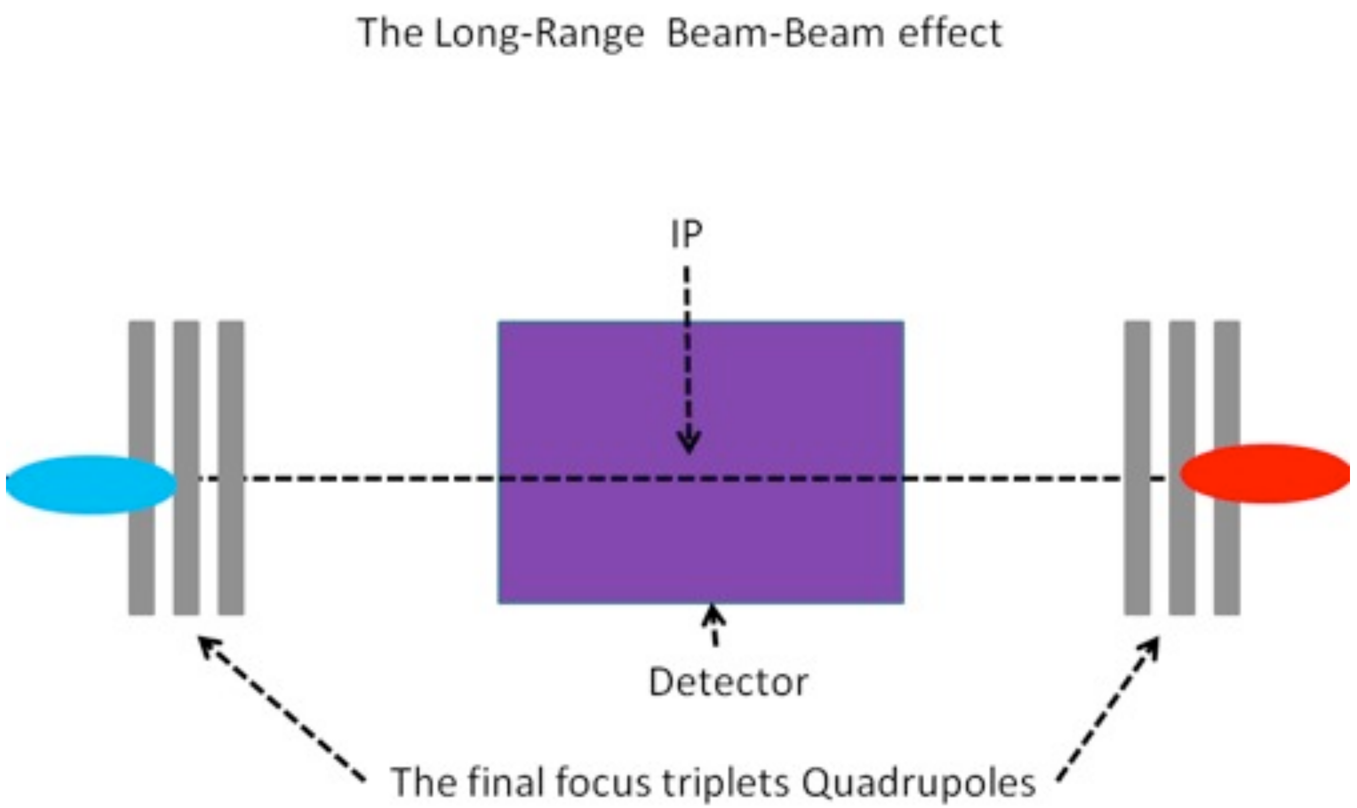
Pto. Vallarta , México 23 de Noviembre del 2010

Scheme

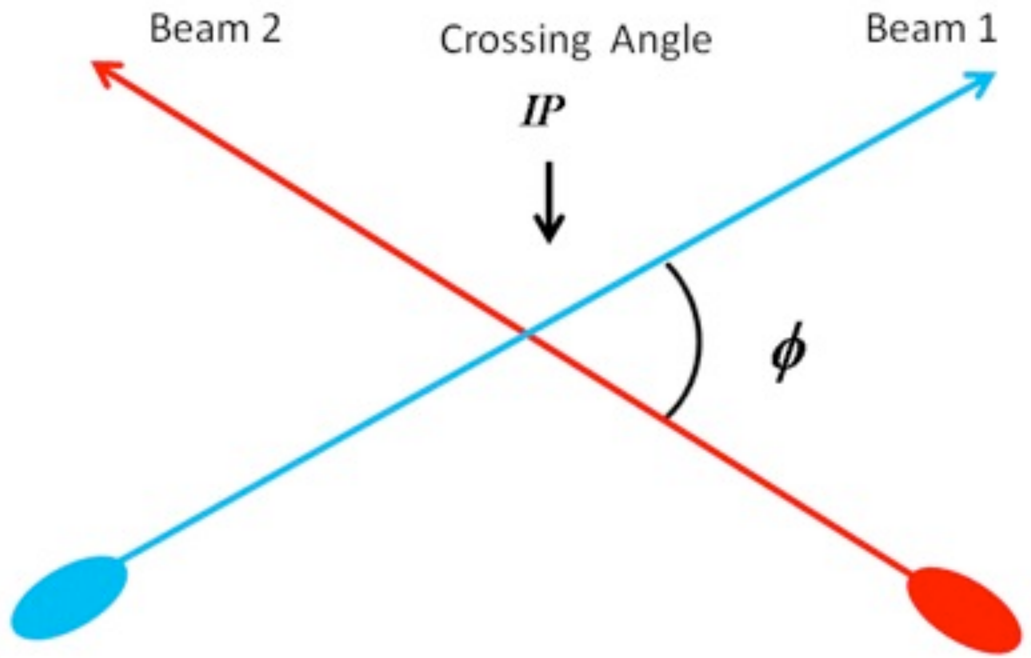
1. Introduction
2. Collimation Studies
3. CC's Failures stage
4. Future work

Introduction

The Long-Range Beam-Beam effect



Crossing Angle



Crab Cavity

Crab Cavities (CC's) can recover the geometric reduction of luminosity due to a crossing angle

The transverse kick of a crab cavity can be represented as

$$\Delta p_x = -\frac{cqV}{E_s}\sin\left(\phi_s + \frac{\omega z}{c}\right)$$

where

V denotes the CC voltage of the CC, ϕ_s the synchronous phase, and ω the crab-RF angular frequency.

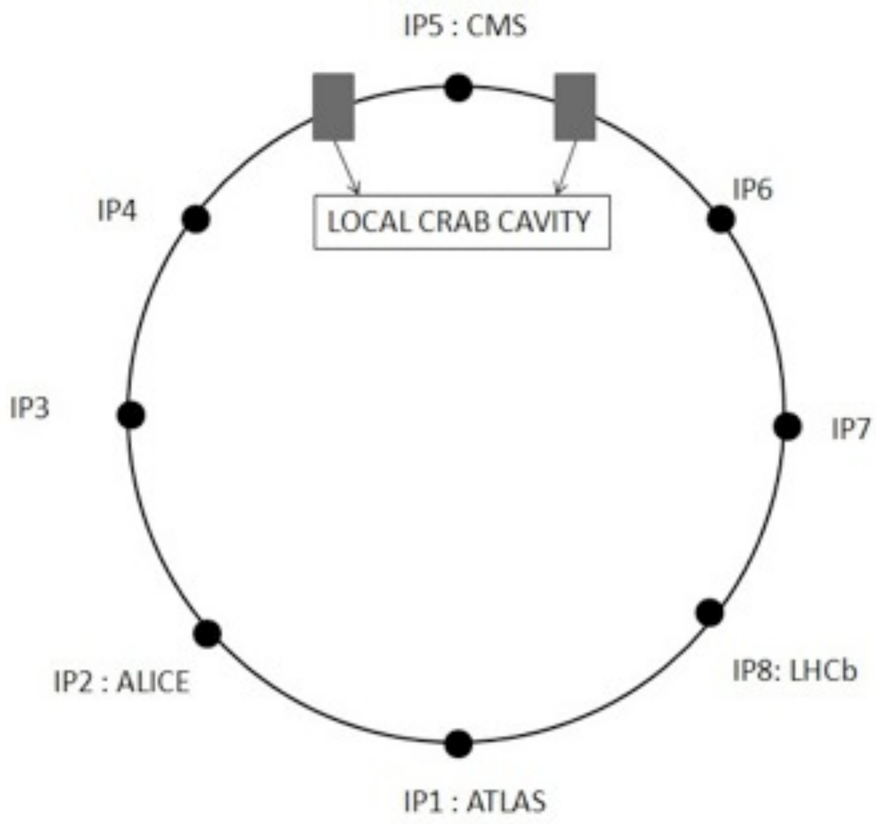
CC Scheme

For the LHC-CC failure scenarios we should consider two different schemes:

1) Local Crab Cavity (LCC)

2) Global Crab Cavity (GCC)

LCC

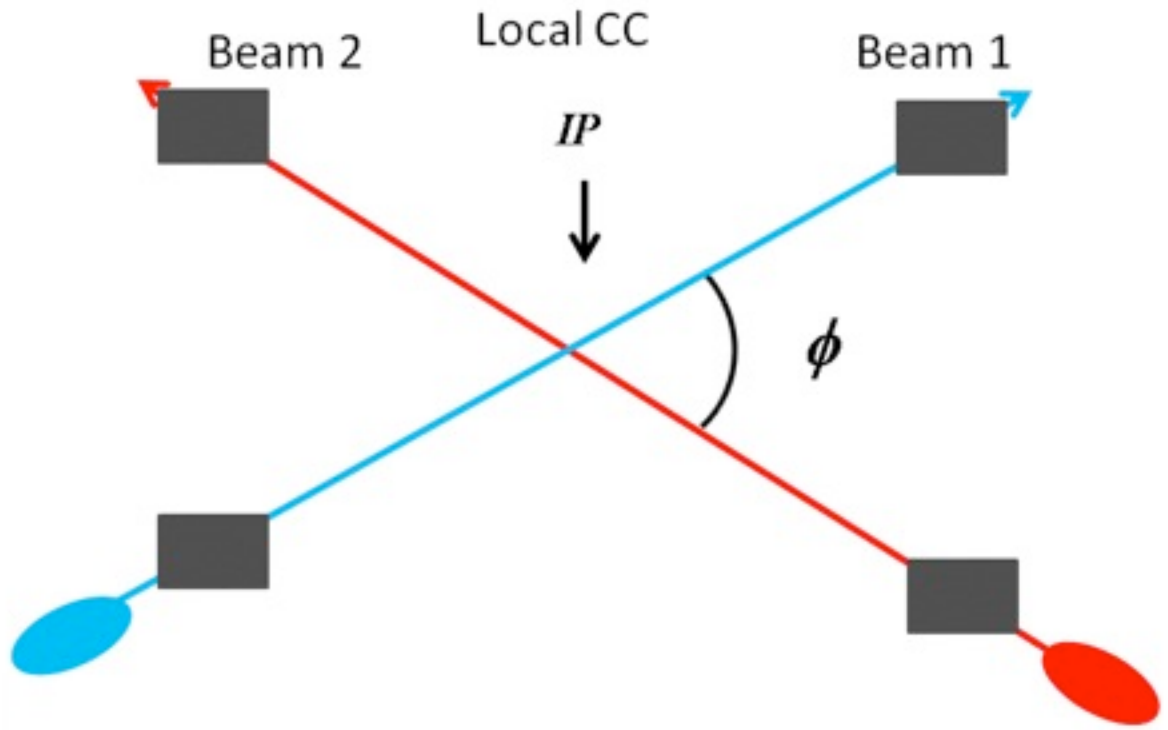


LCC en el LHC

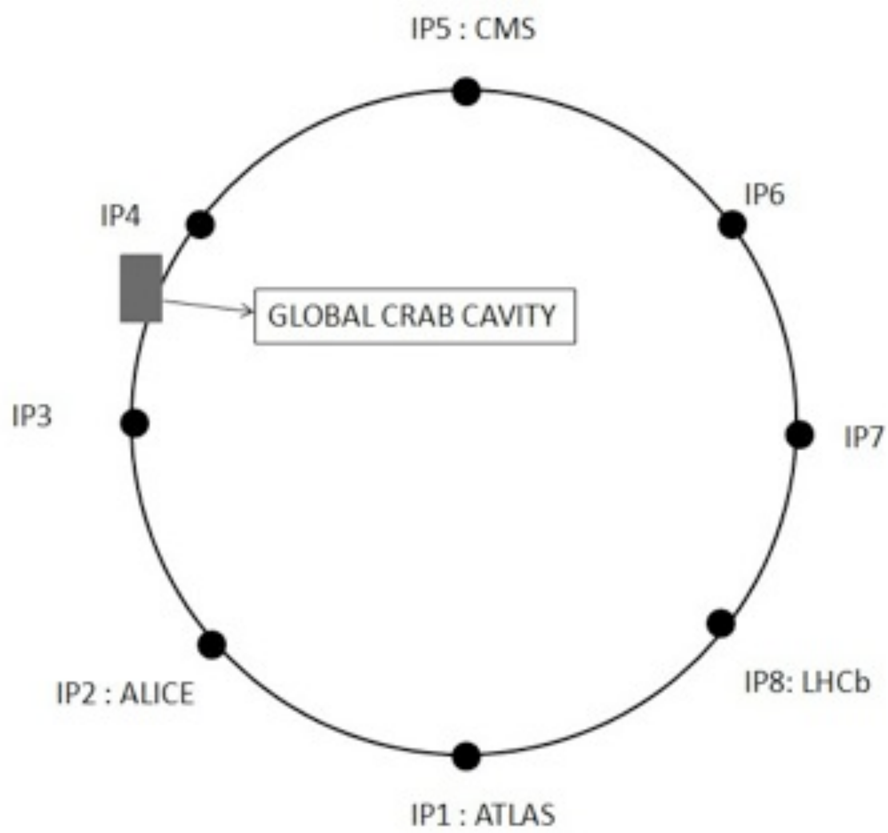
$$V_{ccl} = \frac{cE_s \tan(\frac{\phi}{2})}{q\omega\sqrt{\beta^*\beta_{ccl}}\,\sin(\Delta\psi)}$$

$$V_{ccr} = -R_{22}V_{ccl}$$

LCC



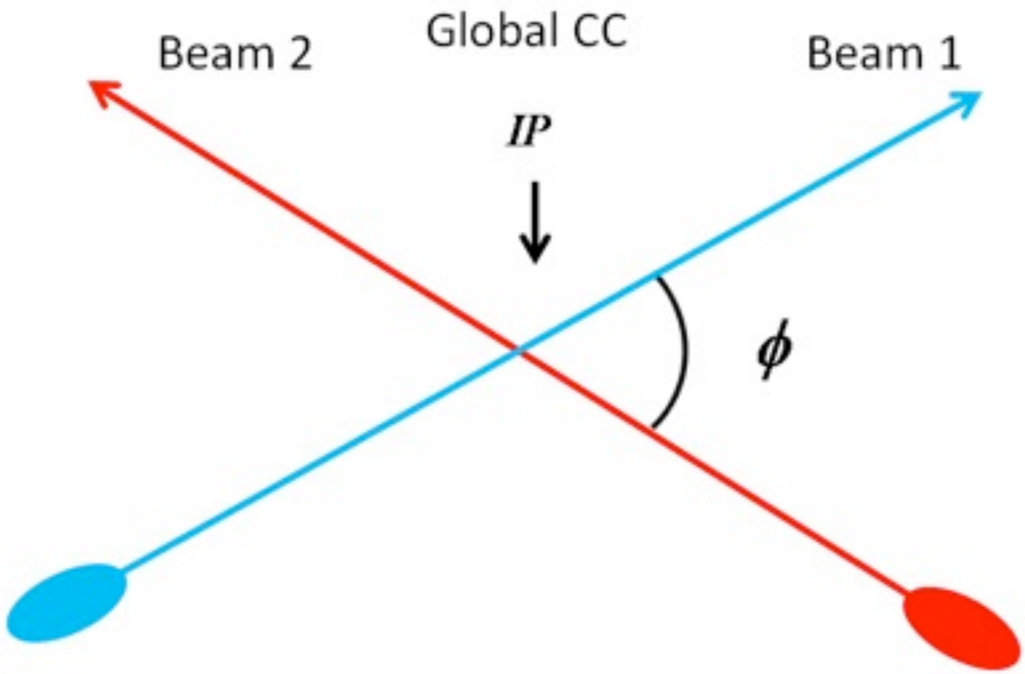
GCC



$$V = \frac{cE_s \tan(\frac{\phi}{2})}{q\omega\sqrt{\beta^*\beta_{crab}}} \left| \frac{2\sin(\pi Q_x)}{\cos(\Delta_1 - \pi Q_x)} \right|$$

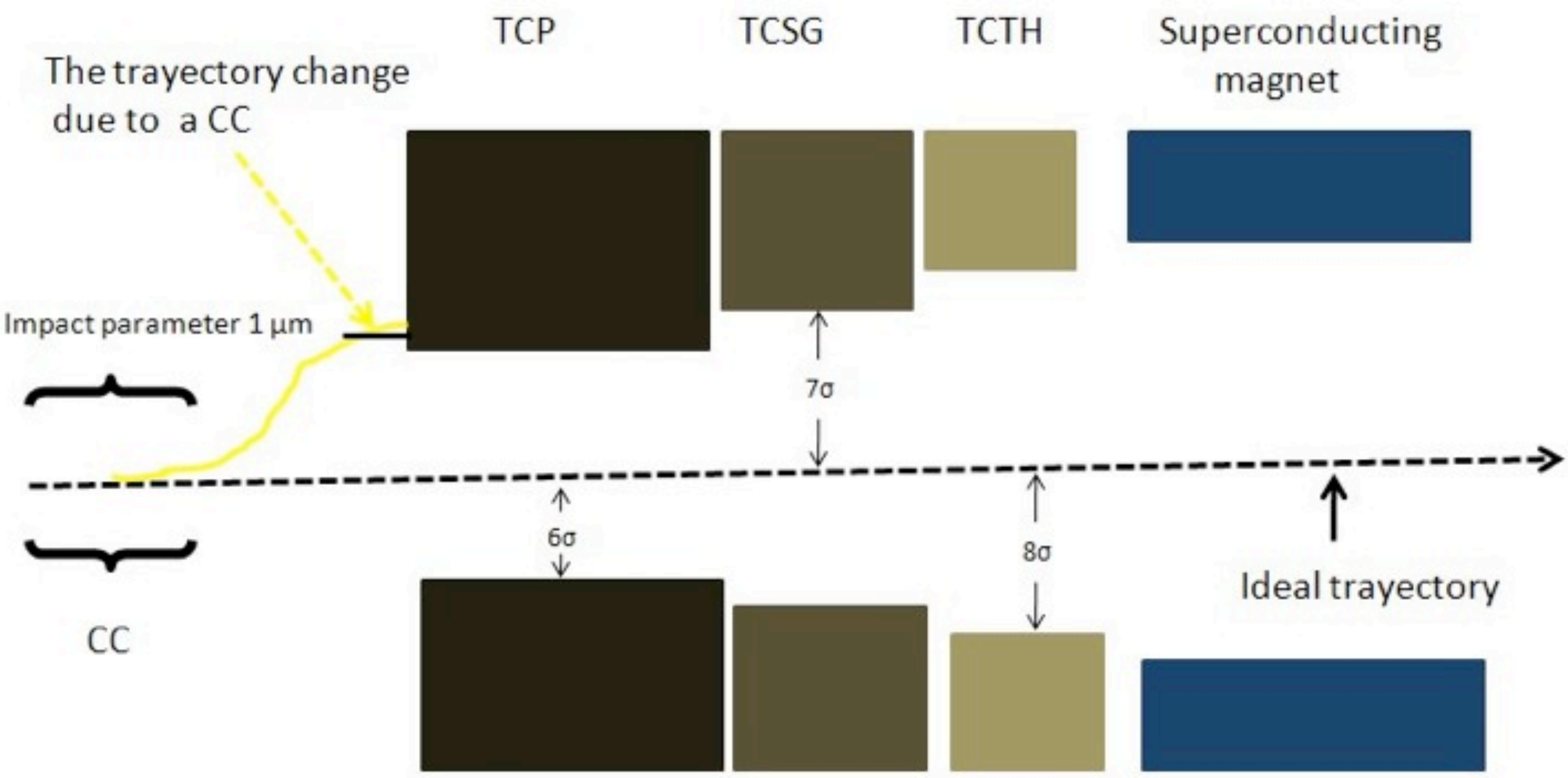
GCC en el LHC

GCC

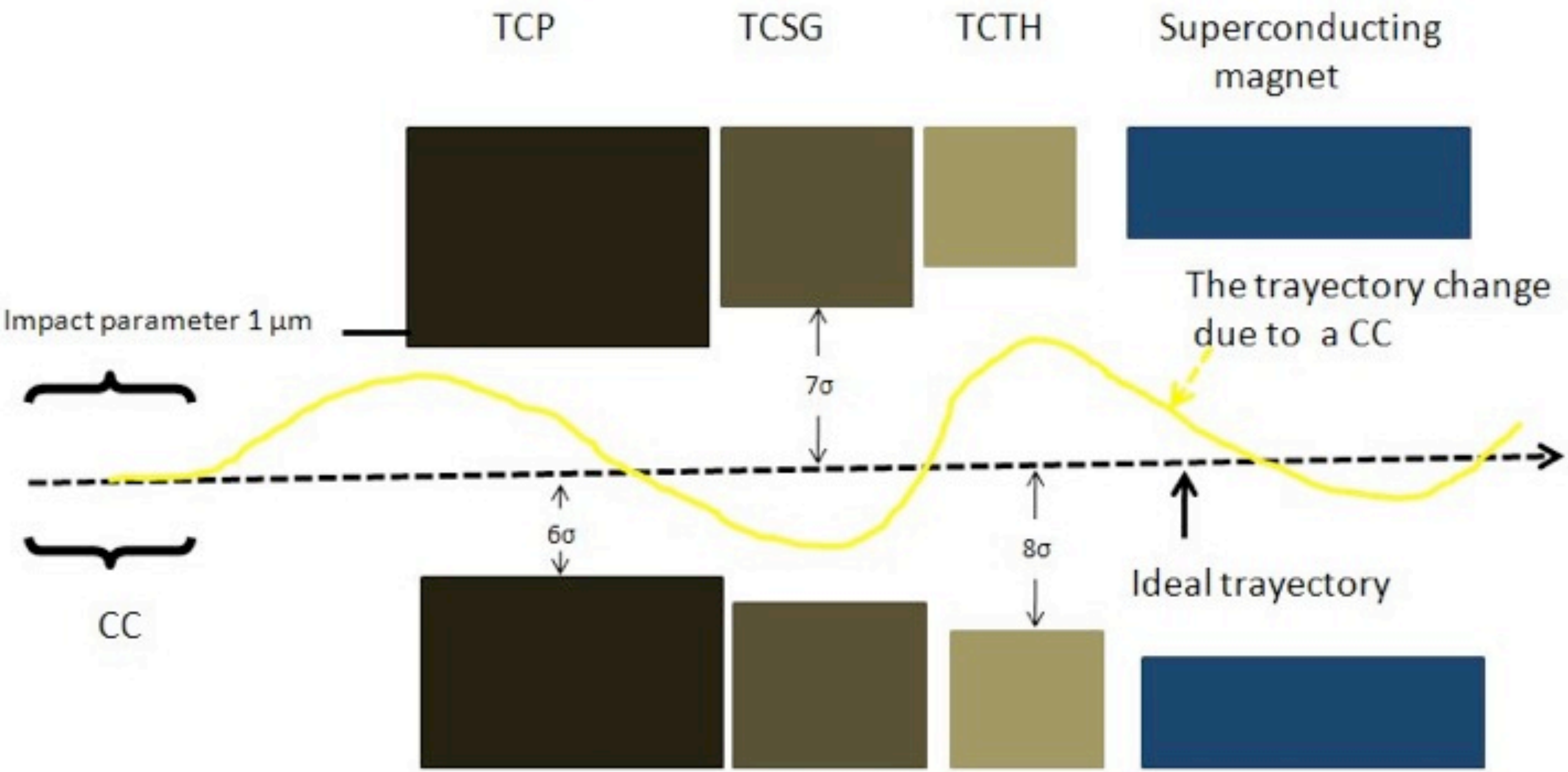


Collimation Studies

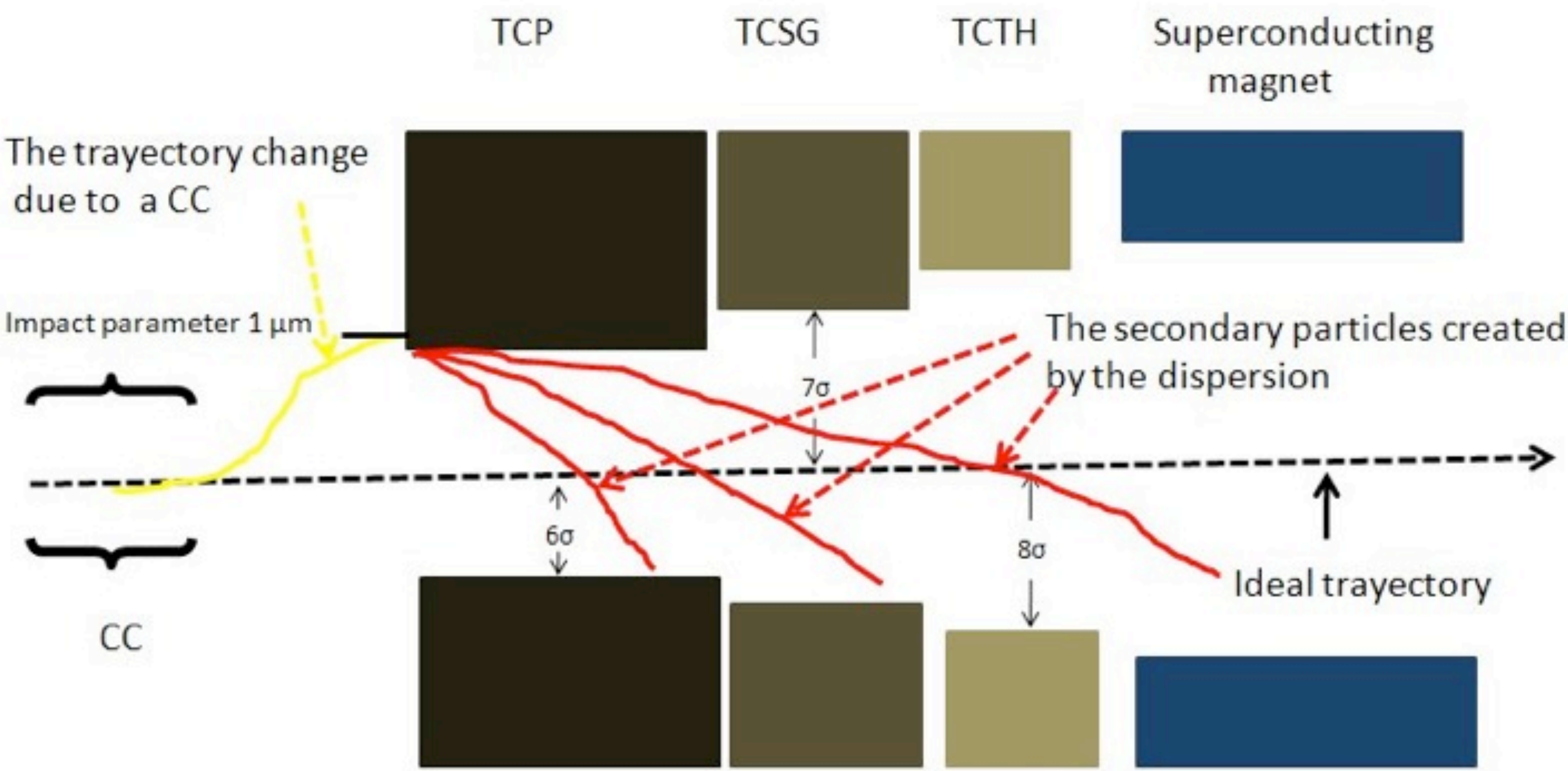
First stage


TCP
TCSG
TCTH
Superconducting magnet
The trayectory change due to a CC
Impact parameter 1 μm
7σ
6σ
8σ
Ideal trayectory
CC

Second stage

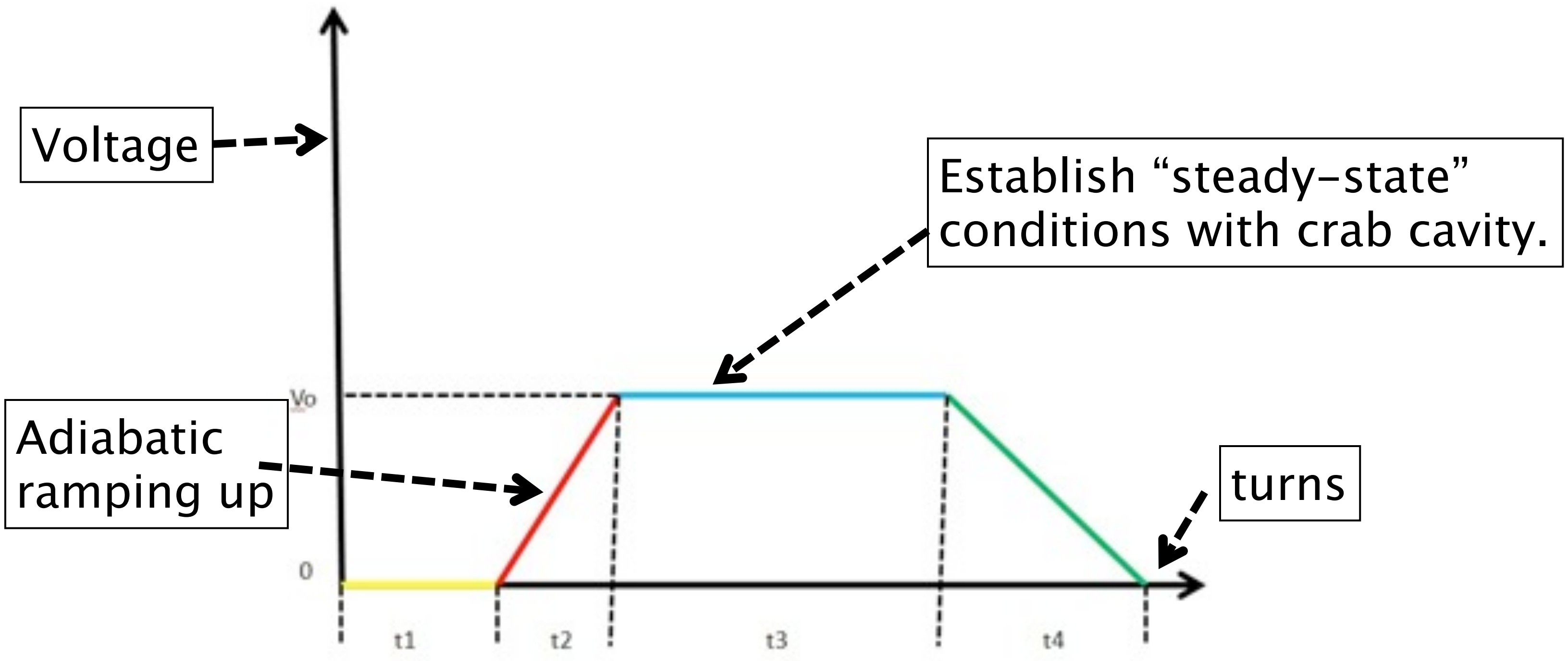


Third stage



TCP
TCSG
TCTH
Superconducting magnet
The trayectory change due to a CC
Impact parameter 1 µm
7σ
The secondary particles created by the dispersion
6σ
8σ
Ideal trayectory
CC

Voltage's ramping



A GCC on the LHC

The simplest case is a single GCC. To simulate a crab-RF failure we vary the crab-RF voltage and the crab-RF phase.

Table 1: Optics Parameters for a GCC

Parameters	[Units]	Value
q	e	1
c	$10^8 \frac{m}{s}$	3
E_s	TeV	7
ϕ	$\mu radians$	285
ω	MHz	800
β_{IP}	m	0.55
β_{CC}	m	255.965
Q		64.31
$\Delta\Psi$	$radians$	7.673

$$V = \frac{cE_s \tan(\frac{\phi}{2})}{q\omega\sqrt{\beta^*\beta_{crab}}} \left| \frac{2\sin(\pi Q_x)}{\cos(\Delta_1 - \pi Q_x)} \right|$$

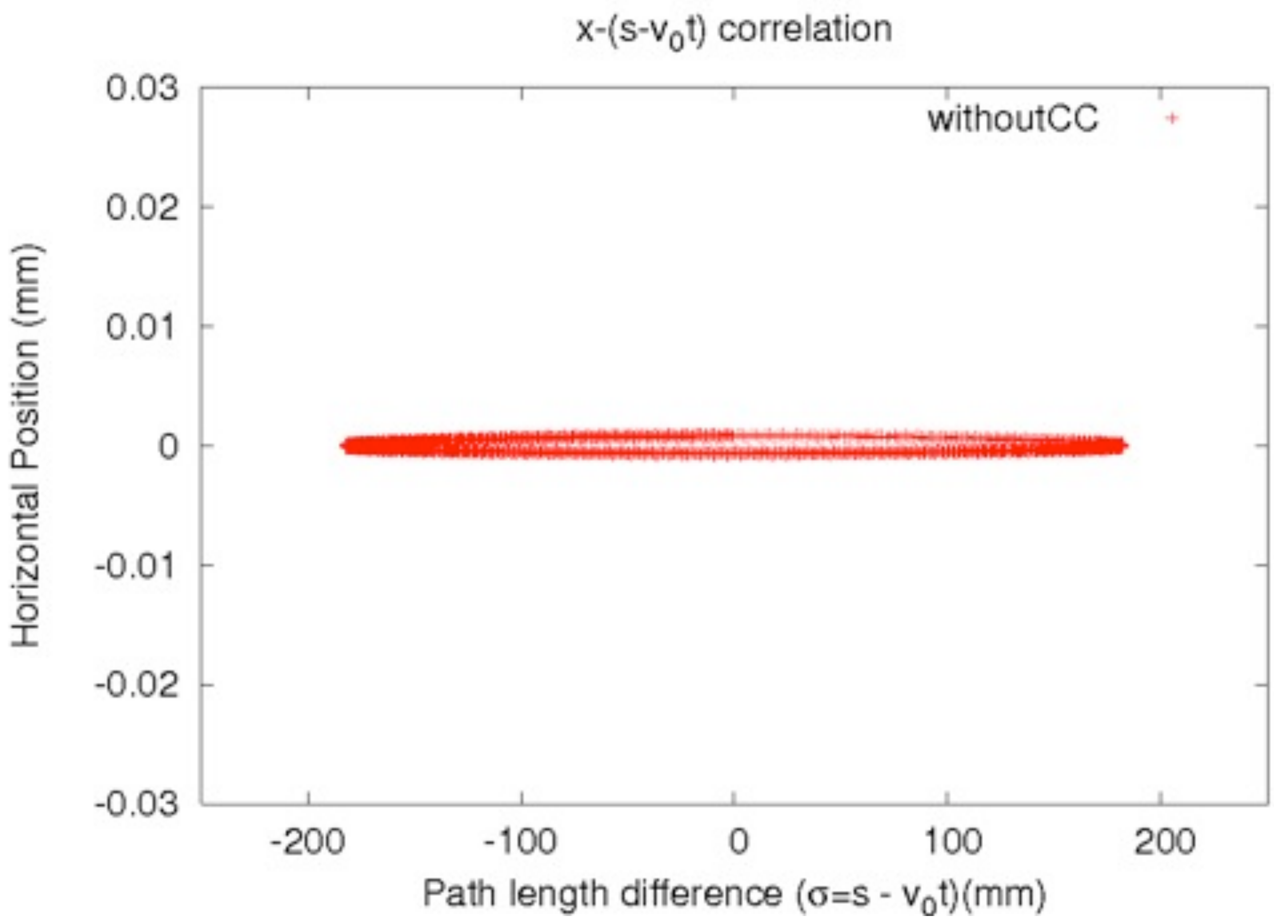
The value of the voltage is

V= 9.07 MV

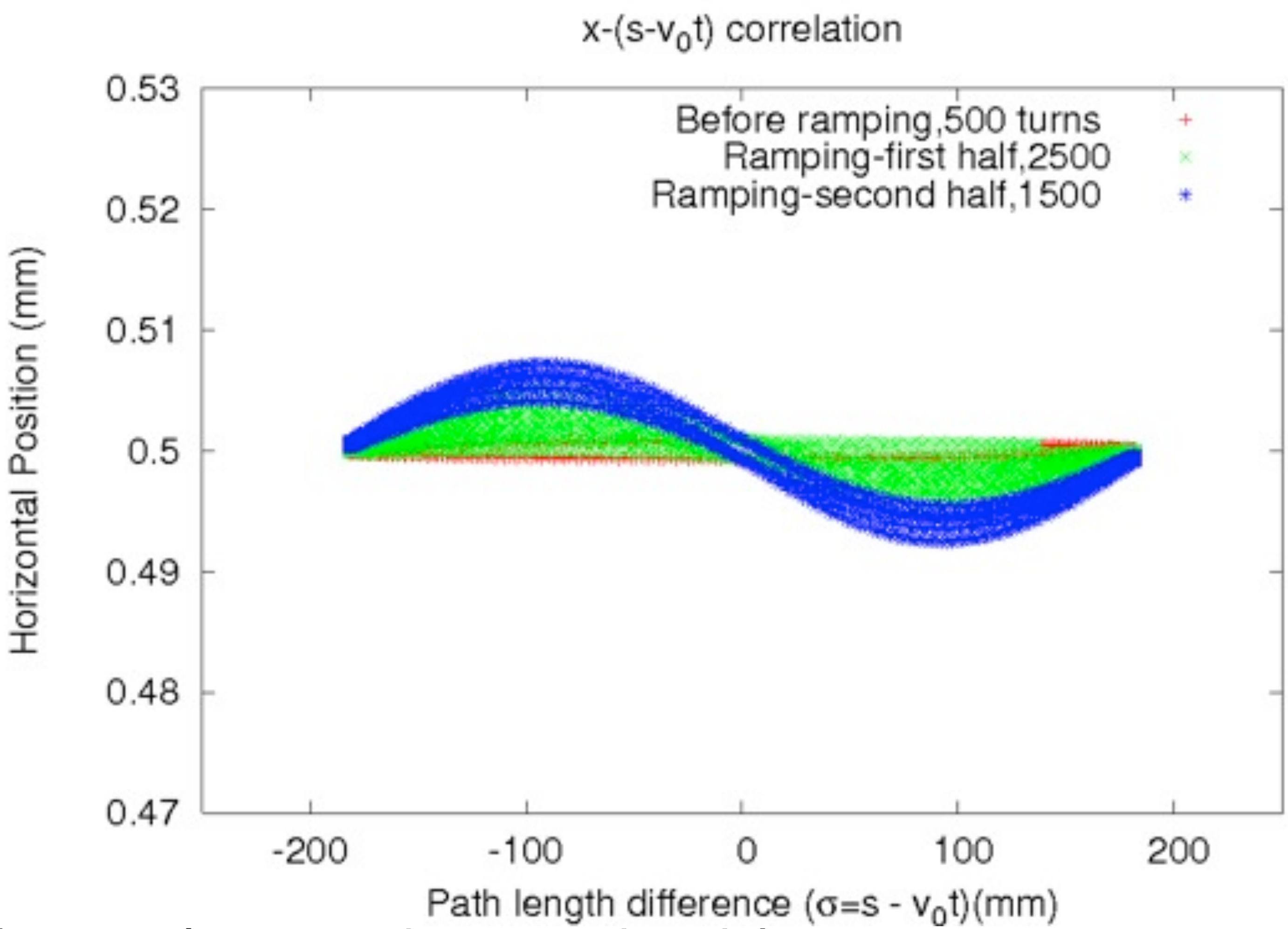
Values of the Nominal de LHC

Parameter	Symbol	Nominal LHC optics	*lowbetamax* optics
Protons per bunch	$N_b[10^{11}]$	1.15	1.15
Number of bunches	n	2808	2808
rms bunch length	σ_z [cm]	7.55	7.55
rms energy spread	$\sigma_e[10^{-4}]$	1.1	1.1
Beta function at IP1 & IP5	β^* [m]	0.55	0.25
Emittance	ϵ [10^{-6} mrad]	3.75	3.75
Full crossing angle	θ [μrad]	285	381

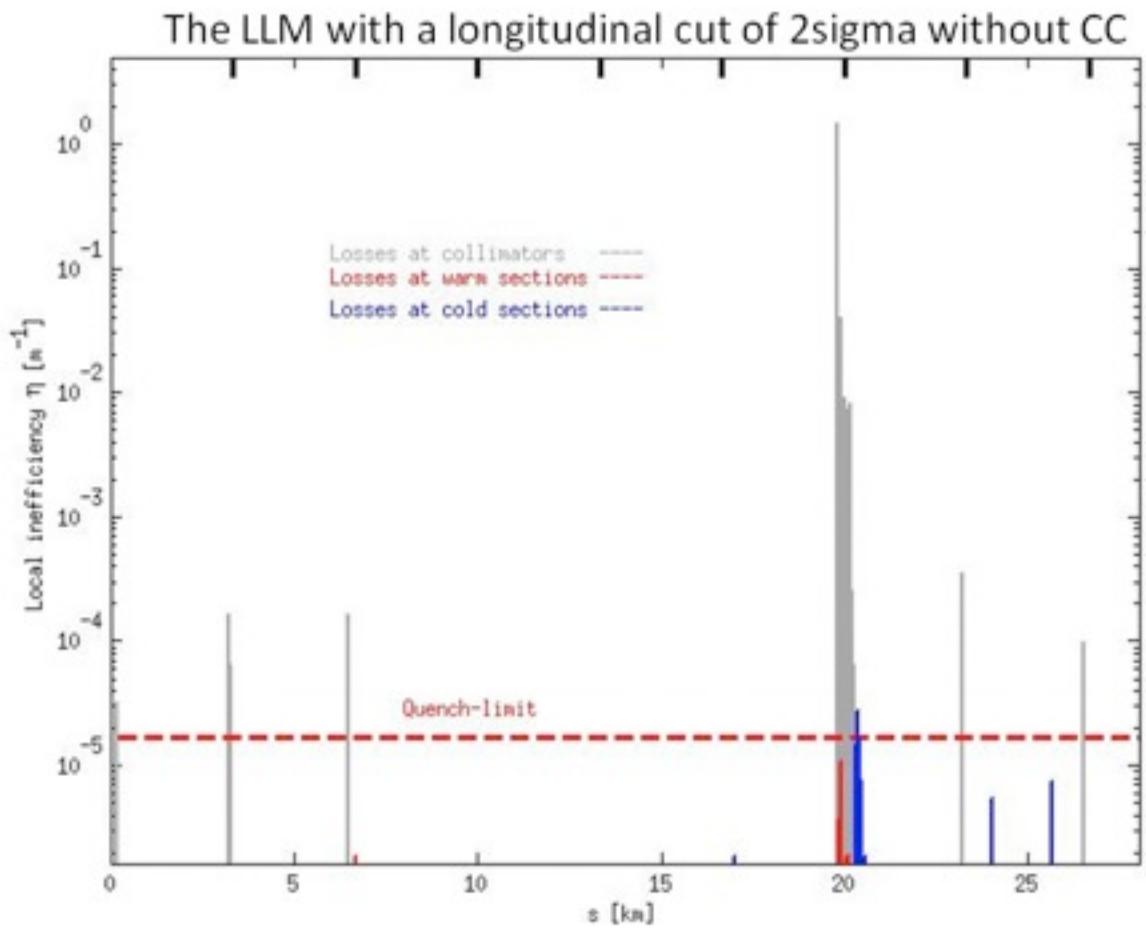
Kick's simulation on the IP



Ramping's simulations

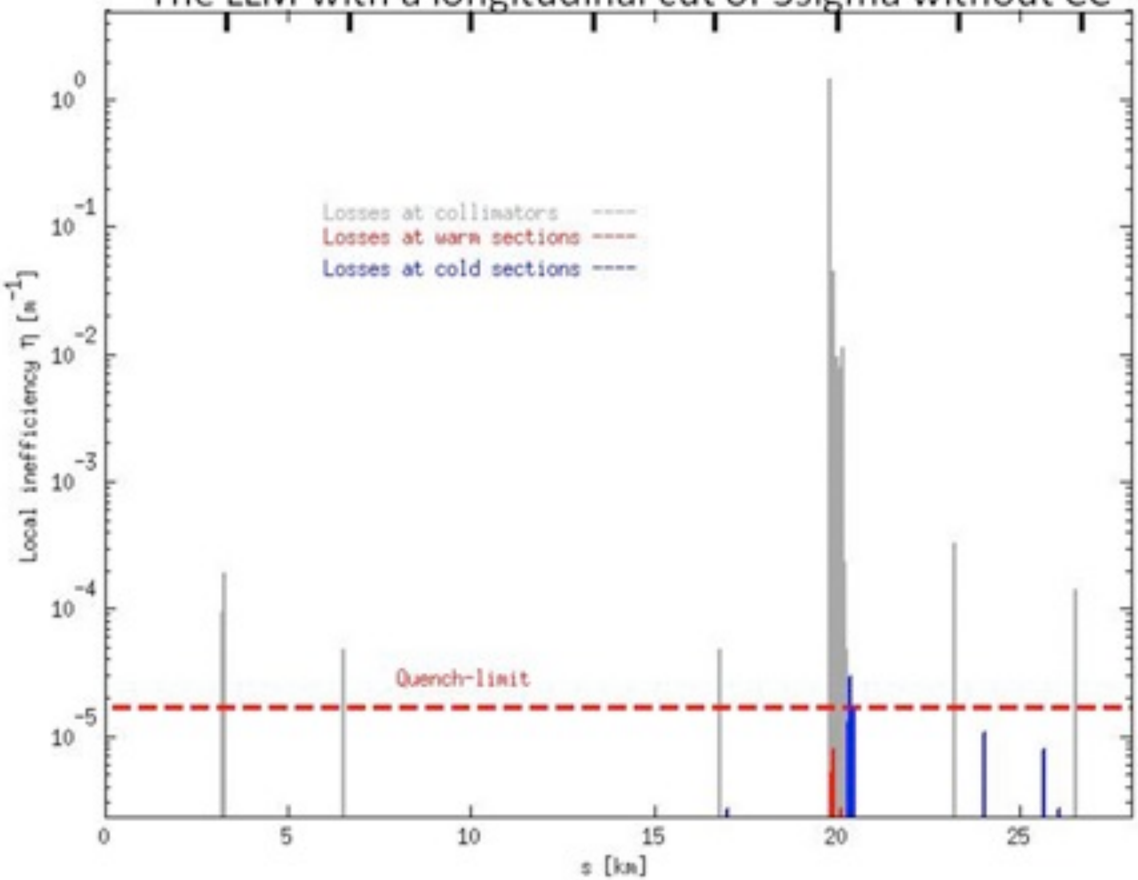


Local Loss Map



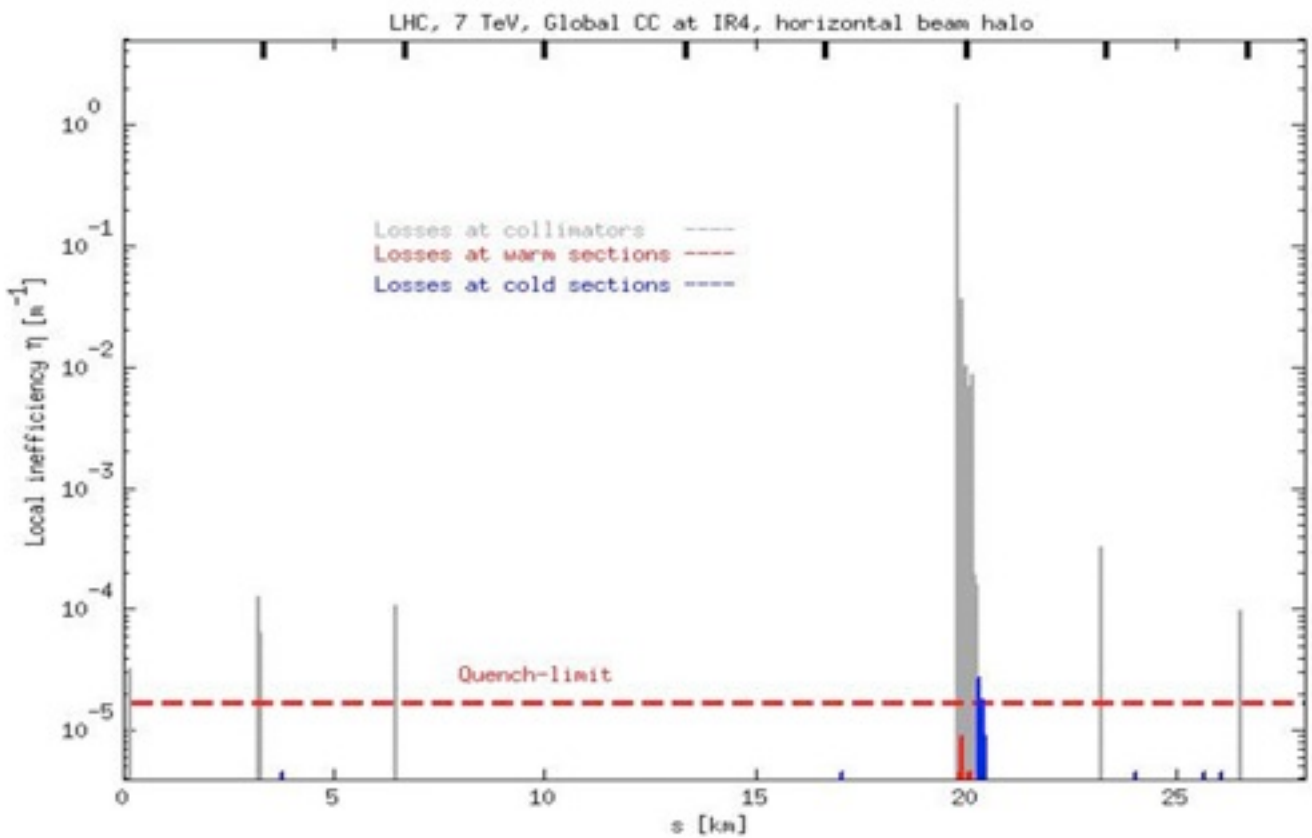
Local Loss Map

The LLM with a longitudinal cut of 3sigma without CC



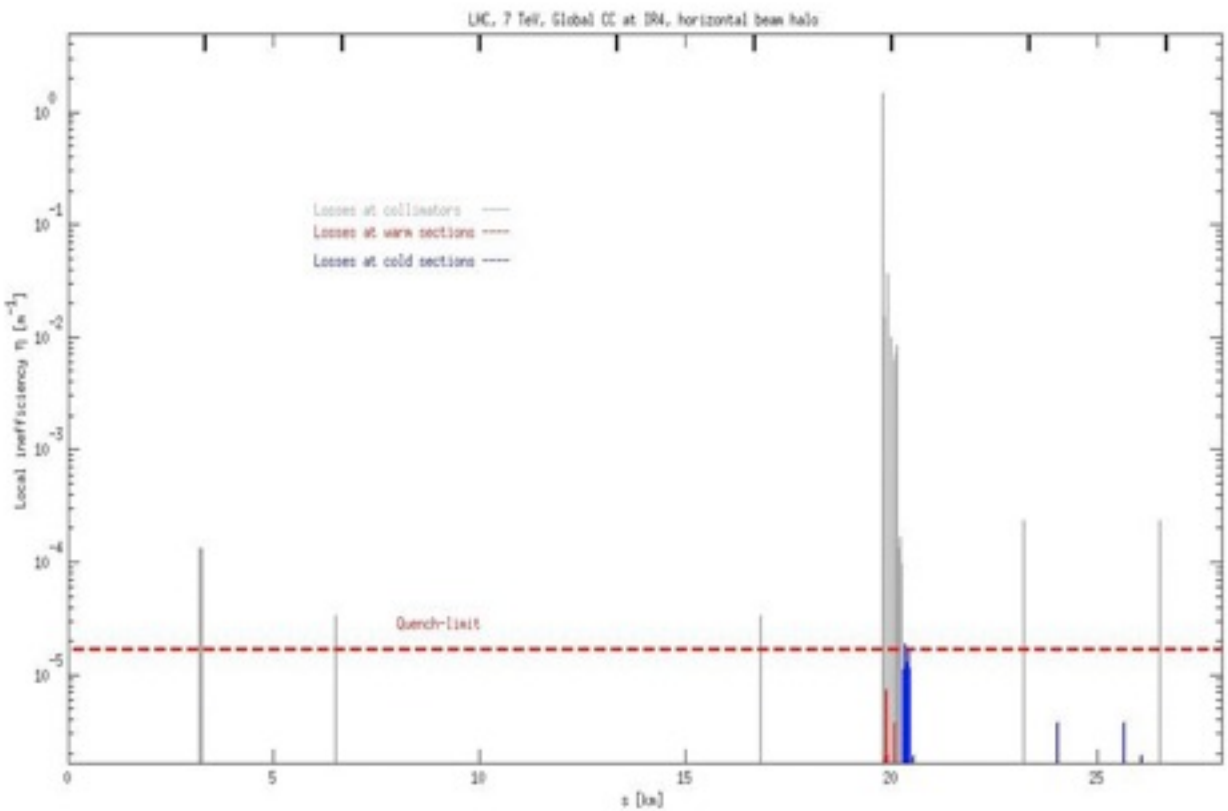
Local Loss Map

The LLM with a Number of ramping up = 1



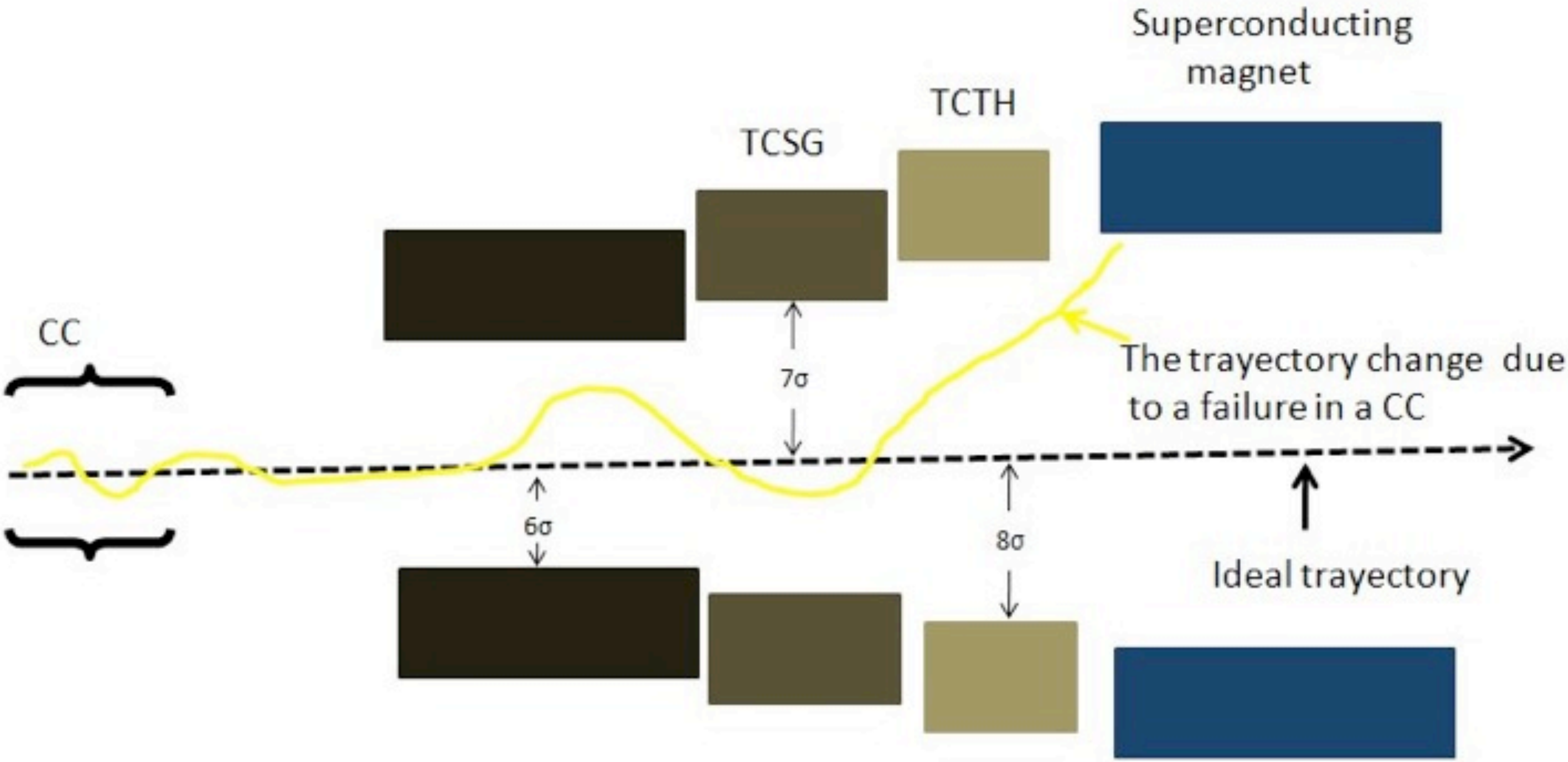
Local Loss Map

The LLM with a horizontal amplitude 5.908σ



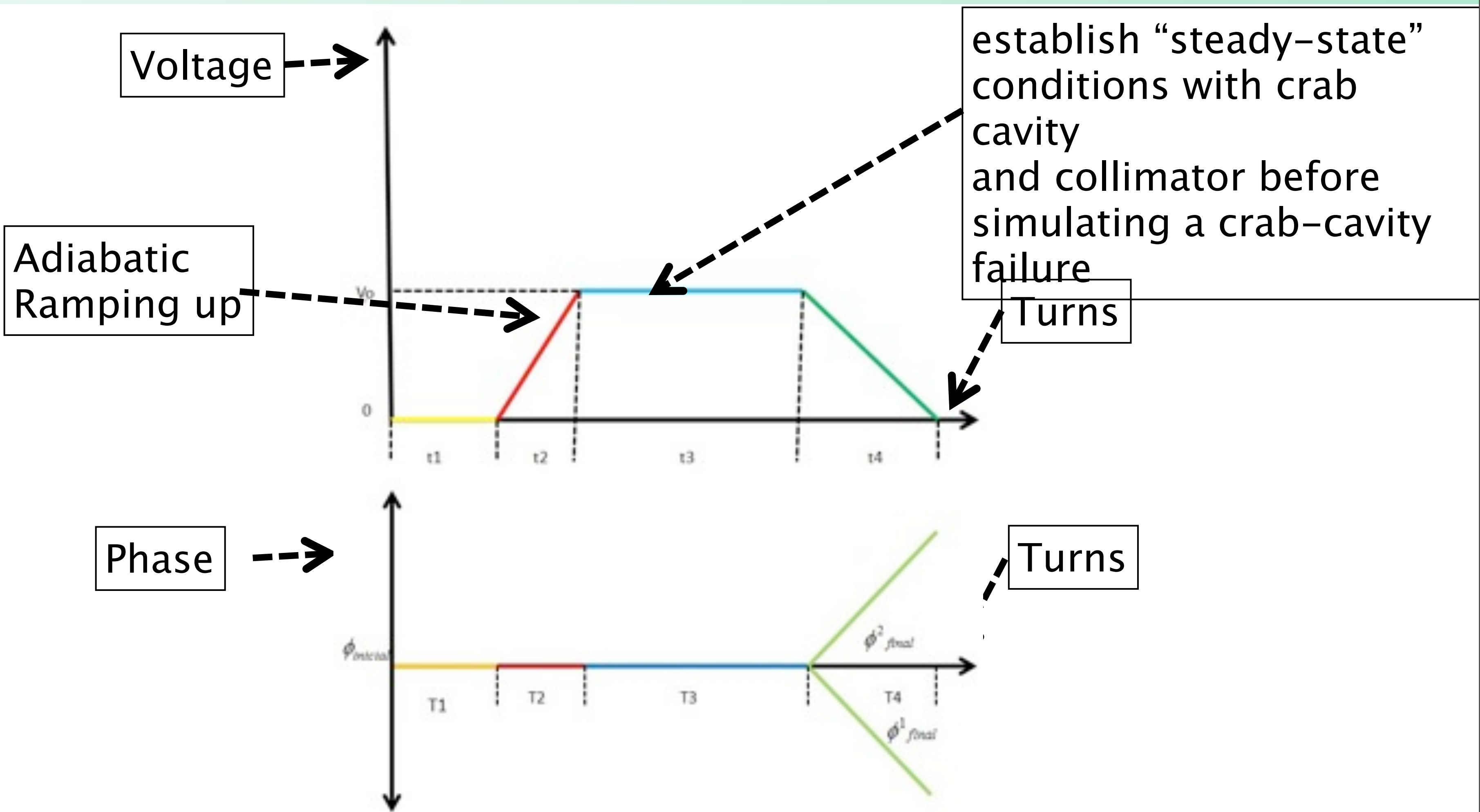
CC’s Failures stage

Stage

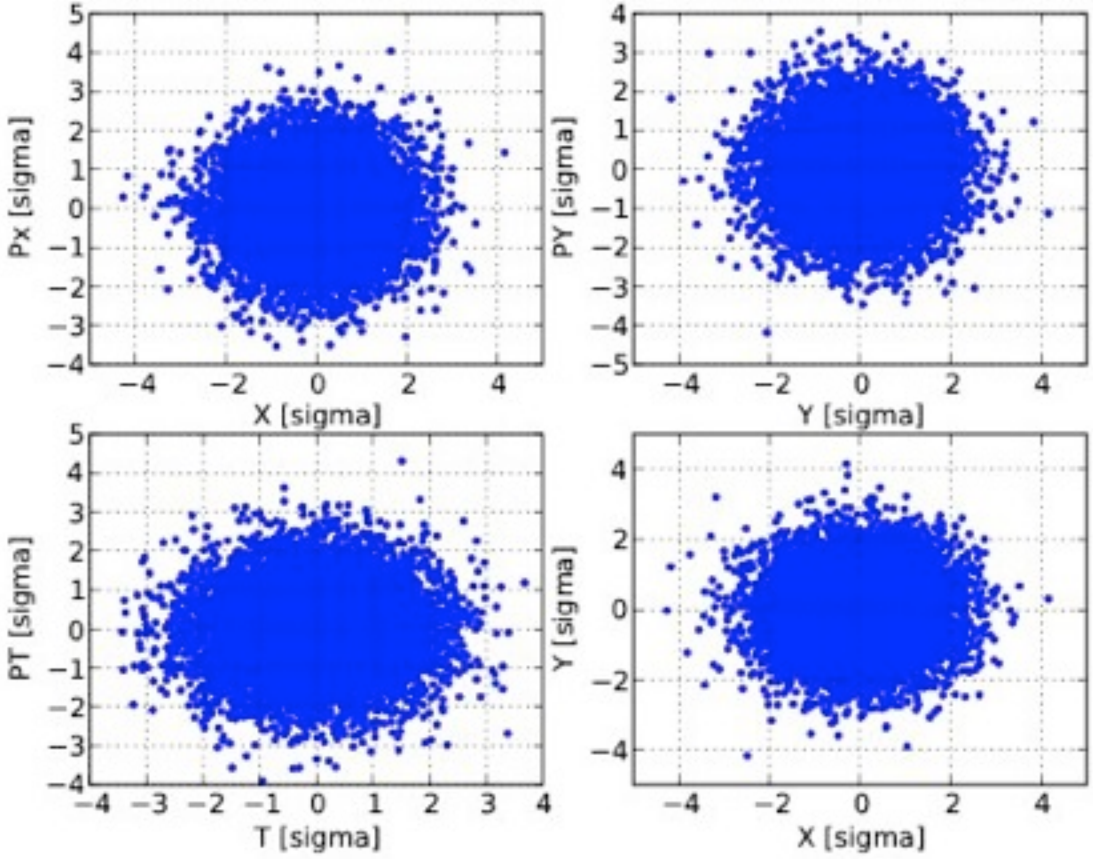


Superconducting magnet
TCTH
TCSG
CC
7σ
The trayectory change due to a failure in a CC
6σ
8σ
Ideal trayectory

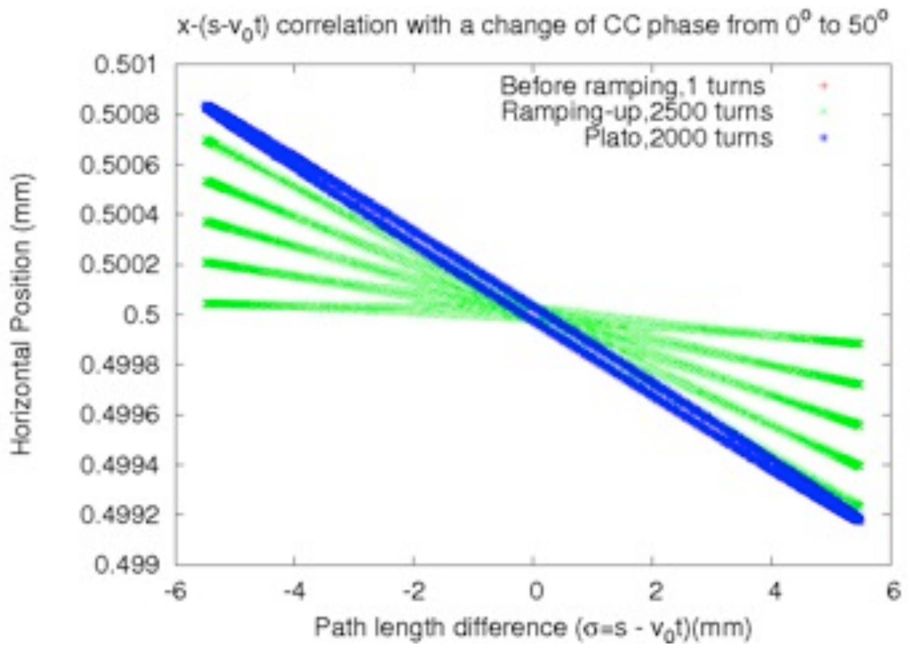
simulation set up for changing CC voltage and phase

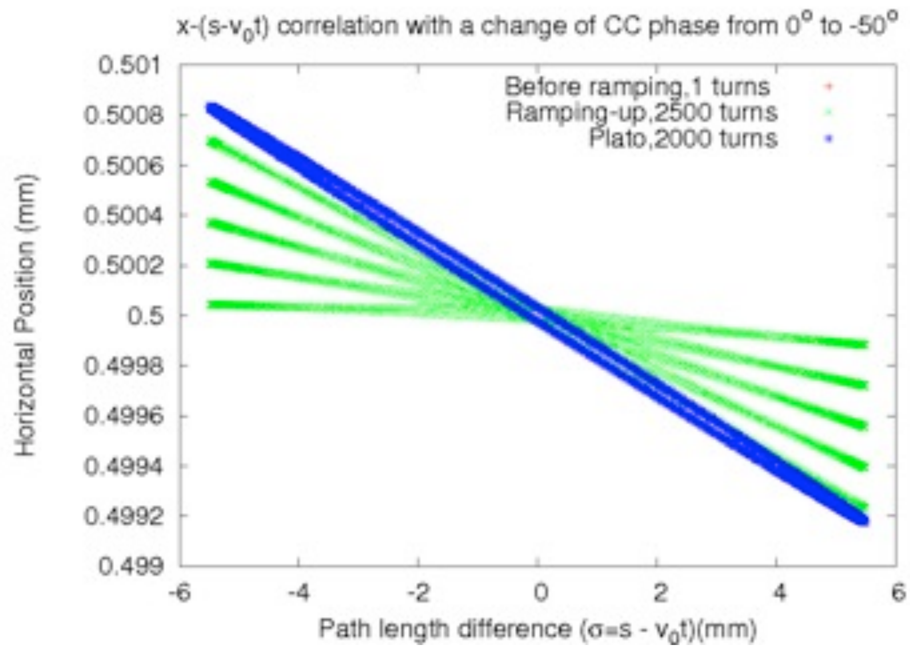


Example of initial particle distribution used as input for Sixtrack



Check of Phase Ramping





A CC phase change steers the beam at the IP as exp

Future work….

- Scan the change of the phase.
- Scan the change in the number of turns of the phase change.
- The study in an upgrade scenario.
- Implement to the LCC.
- Use the RF signals from KEK'B cavities like input on SixTrack.

Acknowledgements

Dr. Javier Barranco, Dr. Rogelio Tomas , Dr. Yi-Peng Sun, Dr. Rama Calaga, Dr. Frank Zimmermann, Dr. Ricardo Lopez; EuCARD-AccNet, CONACYT.

References

-F. Zimmermann and U. Dorda, in Proceedings of LHCLUMI- 05 Workshop, Arcidosso,Italy, 2005 (Report No. CARE-Conf-06-014-HHH).

-Yi-Peng Sun, Phys. Rev. ST Accel. Beams 12, 101002 (2009).

-Bruce Yee Rendón, Crab Cavity Voltage and Luminosity Calculation, http://byee.web.cern.ch/byee/.


Thanks for your attention
...